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Standard Specification for
HARD-DRAWN COPPER-CLAD STEEL WIRE[1]

This Standard is issued under the fixed designation B 227; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval.

1. Scope

1.1 This specification covers bare hard-drawn round copper-clad steel wire for electrical purposes (Explanatory Note 1).

1.2 Four grades of wire are specified, designated as follows (Explanatory Note 2): Grade 40 HS, Grade 40 EHS, Grade 30 HS, and Grade 30 EHS.

NOTE—The values stated in U.S. customary units are to be regarded as the standard. The metric equivalents of U.S. customary units may be approximate.

2. Basis of Purchase

2.1 Orders for material under this specification shall include the following information:

2.1.1 Quantity of each size and grade,

2.1.2 Wire size: diameter in inches (see 6.1 and Table 1),

2.1.3 Grade (see 1.2 and Table 1),

2.1.4 Method of measuring elongation (see 4.3 and 4.4),

2.1.5 Package size (see 13.1),

2.1.6 Special package marking, if required (Section 12), and

2.1.7 Place of inspection (Section 14).

3. Material

3.1 The wire shall be composed of a steel core with a substantially uniform and continuous copper cladding thoroughly bonded to it throughout.

3.2 The finished copper-clad steel wire shall conform to the requirements prescribed in this specification.

4. Tensile Properties

4.1 The wire shall conform to the tensile requirements prescribed in Table 1 (Explanatory Note 4).

4.2 Wire whose nominal diameter is more than 0.001 in. (1 mil) (0.03 mm) greater than a size listed in Table 1 shall conform to the tensile requirements of the next larger size.

4.3 Tension tests shall be made on representative samples. Unless otherwise agreed upon by the manufacturer and the purchaser the elongation shall be determined by measurements made between the jaws of the testing machine. The zero length shall be the distance between the jaws when a load equal to 10 percent of the specified tensile strength shall have been applied, and the final length shall be the distance between the jaws at the time of rupture. The zero length shall be as near 60 in. (1.5 m) as practicable. The fracture shall be between the jaws of the testing machine and not closer than 1 in. (25.4 mm) to either jaw. The elongation as thus determined shall be not less than 1.4 percent.

4.4 When agreed upon by the manufacturer and the purchaser the elongation may be measured by means of an extensometer suitable for measuring elongation in 10 in. (254 mm) and having a vernier reading to 0.01 in. (0.25 mm) attached to the test specimen at a tension load of approximately 10 percent of rated strength. The elongation shall be observed while applying a tension load to the specimen and the reading when fracture occurs shall be taken as the elongation of the specimen. The elongation as thus determined shall be not less than 1.5 percent. Tests in which the extensometer reading is less than 1.5 percent, but in which the fracture does not occur between the two attachments of the extensometer to the specimen, shall be disregarded.

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[1] This specification is under the jurisdiction of the ASTM Committee B-1 on Wires for Electrical Conductors. A list of members may be found in the ASTM Yearbook.

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4.5 *Retests*—If upon testing a sample from any coil or spool of wire, the results do not conform to the tensile requirements prescribed in Table 1 and the elongation requirements of 4.4, two additional samples shall be tested, and the average of the three tests shall determine the acceptance or rejection of the coil or spool.

5. Resistance

5.1 The electrical resistance of the wire (Explanatory Notes. 4 and 5) shall be determined by resistance measurements and maximum resistance shall be based on the nominal diameter of the wire and the resistivity values prescribed in Table 2.

5.2 Resistance readings on the selected test specimen shall meet the requirements as specified for ends of coils in Table 2. Tests of resistance at center of coils shall be made on the sample coils from which the test specimens were taken.

5.3 When resistance measurements are made at temperatures other than 68 F (20 C), corrections shall be based on a temperature coefficient of resistance of 0.0021/deg F (0.0038/deg C).

5.4 Tests to determine conformance to the electrical resistance requirements of Table 2 shall be made in accordance with ASTM Method B 193, Test for Resistivity of Electrical Conductor Materials.[2]

6. Dimensions and Permissible Variations

6.1 The size shall be expressed as the diameter of the wire in decimal fractions of an inch; using four places of decimals, that is, in tenths of mils (Explanatory Note 3).

6.2 Within the range of diameters included in Table 1 the wire shall not vary from the specified diameter by more than the following amounts rounded off to the nearest 0.1 mil (0.0001 in.):

Specified Diameter, in. (mm)	Permissible Variations in Specified Diameter, plus and minus
0.2043 (5.189) to 0.1000 (2.540), incl	1.5 percent
0.1000 (2.540) to 0.0800 (2.032), incl	0.0015 in. (1.5 mils) (0.038 mm)

6.3 Ten percent, but not less than five coils or spools (or all if the lot is less than five) from any lot of wire shall be gaged at three places. If accessible, one gaging shall be taken near each end and one near the middle. If any of the selected coils or spools fail to conform to the requirements for diameter as prescribed in 6.2, all coils or spools shall be gaged in the manner specified.

7. Density

7.1 For the purpose of calculating weights, cross sections, etc., the density of the wire shall be taken as 8.15 g/cm^3 (0.29444 lb/in.^{3}) at 20 C (68 F).

8. Thickness of Copper

8.1 The thickness of copper on the wire shall be not less than that shown in Table 3. The copper thickness may be determined by direct measurements of cross sections of the wire or by means of a suitable electrical indicating instrument operating on the permeameter principle.

9. Twist Test

9.1 The wire shall withstand without fracture not less than 20 twists in a length equivalent to 100 times the nominal diameter of the specimen. In the twist test, the rate of applying the twists shall be approximately 15/min.

9.2 Specimens shall be twisted to destruction and shall not reveal under test any seams, pits, slivers or surface imperfections of sufficient magnitude to indicate inherent defects or imperfections in the wire. Examination of the wire at the break shall show no separation of copper from the steel.

10. Joints

10.1 The finished wire shall contain no joints or splices (Explanatory Note 6).

11. Finish

11.1 The surface of the wire shall be smooth and free from imperfections not consistent with good commercial practice.

12. Marking

12.1 Each coil shall bear a tag showing the manufacturers' name or trademark, size, and class of material. If additional information is to be required on the tags, it shall be arranged with the manufacturer at the time of purchase.

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[2] *Annual Book of ASTM Standards*, Part 5.

13. Packaging and Shipping

13.1 Package sizes shall be agreed upon by the manufacturer and the purchaser in the placing of individual purchase orders.

13.2 The wire shall be protected against damage in ordinary handling and shipping.

14. Inspection

14.1 All tests and inspection shall be made at the place of manufacture unless otherwise especially agreed upon between the manufacturer and the purchaser at the time of purchase. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material is being furnished in accordance with this specification.

EXPLANATORY NOTES

NOTE 1—Wire ordered to this specification is not intended for redrawing. If wire is desired for this purpose the manufacturer should be consulted.

NOTE 2—The grades covered by this specification correspond to the following commercial designations:

Grade 40 HS, High Strength, 40 percent Conductivity.

Grade 40 EHS, Extra High Strength, 40 percent Conductivity.

Grade 30 HS, High Strength, 30 percent Conductivity.

Grade 30 EHS, Extra High Strength, 30 percent Conductivity.

NOTE 3—The values of wire diameters in Table 1 are given to the nearest 0.0001 in. and correspond to the standard sizes given in ASTM Specification B 258, for Standard Nominal Diameters and Cross-Sectional Areas of Awg Sizes of Solid Round Wires Used as Electrical Conductors.[2] In specifying diameters of wire or in inspecting wire, the diameter should also be expressed to the fourth decimal place. The diameters preceded by asterisks are not in the American Wire Gage series and are also given to four places of decimals. They correspond to certain of the numbers of the Birmingham Wire Gage or of the British Standard Wire Gage and are used for communication lines. The use of gage numbers in specifying wire sizes is not recognized in these specifications because of the possibility of confusion. An excellent discussion of wire gages and related subjects is contained in *NBS Handbook 100* of the National Bureau of Standards.[3]

NOTE 4—The approximate properties of hard-drawn copper-clad steel wire are shown in Table 4 for the information of the user of this specification.

NOTE 5—Electrical resistance is calculated by the following equation:

$$\text{Resistance (ohms per foot)} = \frac{\text{Resistivity, ohm} \cdot \text{circular mil/ft}}{(\text{Nominal diameter, mils})^2}$$

NOTE 6—Mechanical joints made during inspection at the request of the purchaser are permissible if agreed upon at the time of placing the order.

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[3] *NBS Handbook 100* may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402.

TABLE 1 Tensile Requirements

Nominal Diameter, in.	Area at 20 C (68 F)		Tensile Strength, min, psi[b]			
	cmil	in.[2, b]	Grade 40 HS	Grade 40 EHS	Grade 30 HS	Grade 30 EHS
0.2043	41 740	0.03278	108 000	...	120 000	142 500
0.1819	33 090	0.02599	113 000	...	125 000	150 500
0.1650[a]	27 230	0.02138	118 000	...	130 000	157 500
0.1620	26 240	0.02061	118 000	...	130 000	157 500
0.1443	20 820	0.01635	123 000	...	135 000	164 000
0.1285	16 510	0.01297	128 000	...	140 000	170 000
0.1280[a]	16 380	0.01287	128 000	...	140 000	170 000
0.1144	13 090	0.01028	133 000	...	145 000	174 100
0.1040[a]	10 820	0.008495	138 600	156 000	151 000	175 000
0.1019	10 380	0.008155	138 600	...	151 000	179 000
0.0808	6 530	0.005129	153 100	...	...	...
0.0800[a]	6 400	0.005027	153 200	...	...	179 000

[a] These diameters are often employed by purchasers for communication lines but are not in the American Wire Gage (B & S Wire Gage) series, as are the other diameters listed (Explanatory Note 3).

[b] Metric equivalents: 1 in. = 25.4 mm (round to 4 significant figures); 1 in.^{2} = 645.16 mm^2 (round to 4 significant figures); 1 psi = 0.000703 (round to significant figure of U.S. customary units).

TABLE 2 Resistivity Values

Grade	Resistivity at 20 C (68 F), max, Ω · cmil/ft	
	Mid-Half of Coil	Ends of Coil
40 HS and 40 EHS	26.45	28.59
30 HS and 30 EHS	35.26	39.18

TABLE 3 Thickness of Copper Cladding

Nominal Diameter in.	Thickness of Copper, min, mils[a]	
	Grades 40 HS and 40 EHS	Grades 30 HS and 30 EHS
Under 0.2100 to 0.2000, incl	12	10
Under 0.2000 to 0.1800, incl	11	9
Under 0.1800 to 0.1600, incl	10	8
Under 0.1600 to 0.1500, incl	9	7
Under 0.1500 to 0.1400, incl	8	7
Under 0.1400 to 0.1300, incl	8	6
Under 0.1300 to 0.1200, incl	7	6
Under 0.1200 to 0.1100, incl	6	5
Under 0.1100 to 0.1000, incl	6	5
Under 0.1000 to 0.0800, incl	5	4

[a] Metric equivalents: 1 in. = 25.40 mm (round off to 4 significant figures); 1 mil = 0.0254 mm (round off to 2 decimal places).

TABLE 4 Approximate Properties[a] of Hard-Drawn Copper-Clad Steel Wire

(For Information Only)

Nominal Diameter, in.	Breaking Strength, min, lb				Resistance at 20 C (68 F), Ω/1000 ft		Average Weight, lb[b]	
	Grade 40 HS	Grade 40 EHS	Grade 30 HS	Grade 30 EHS	Grades 40 HS and 40 EHS	Grades 30 HS and 30 EHS	per 1000 ft	per Mile
0.2043	3541	. . .	3934	4672	0.6337	0.8447	115.8	611.6
0.1819	2938	. . .	3250	3913	0.7990	1.065	91.86	485.0
0.1650	2523	. . .	2780	3368	0.9715	1.295	75.55	398.9
0.1620	2433	. . .	2680	3247	1.008	1.343	72.85	384.6
0.1443	2011	. . .	2207	2681	1.270	1.694	57.77	305.0
0.1285	1660	. . .	1815	2204	1.602	2.136	45.81	241.9
0.1280	1647	. . .	1802	2188	1.614	2.152	45.47	240.1
0.1144	1368	. . .	1491	1790	2.020	2.693	36.33	191.8
0.1040	1177	1325	1283	1487	2.445	3.260	30.01	158.5
0.1019	1130	. . .	1231	1460	2.547	3.396	28.81	152.1
0.0808	785	. . .	. . .	. . .	4.051	. . .	18.12	95.68
0.0800	770	. . .	. . .	900	4.133	5.509	17.76	93.77

[a] Metric equivalents: 1 in. = 25.40 mm (round off to 4 significant figures); 1 lb = 0.45359 kg (round off to 4 significant figures); 1 lb/1000 ft = 1.48816 kg/km (round off to 4 significant figures); 1 Ω/1000 ft = 3.281 Ω/km (round off to 4 significant figures).

[b] Based on a density of 8.15 g/cm^3 (0.29444 lb/in.^{3}). A corresponding value is 0.000 002 775 lb/cmil · ft.